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xDrive / DSC

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xDrive/DSC

Model: E83/ E53 MU (Model Update)

**Production: E83 - Start of Production MY 2004
E53 MU - 9/03**

OBJECTIVES

After completion of this module you will be able to:

- Explain the xDrive mechanical operation
- Describe the xDrive power flow
- Identify the coding resistor and understand its purpose
- Diagnose the VGSG control of the multi-disc clutch
- Perform an “on vehicle” test to verify xDrive function
- Explain the Oil change procedure found in Service Functions

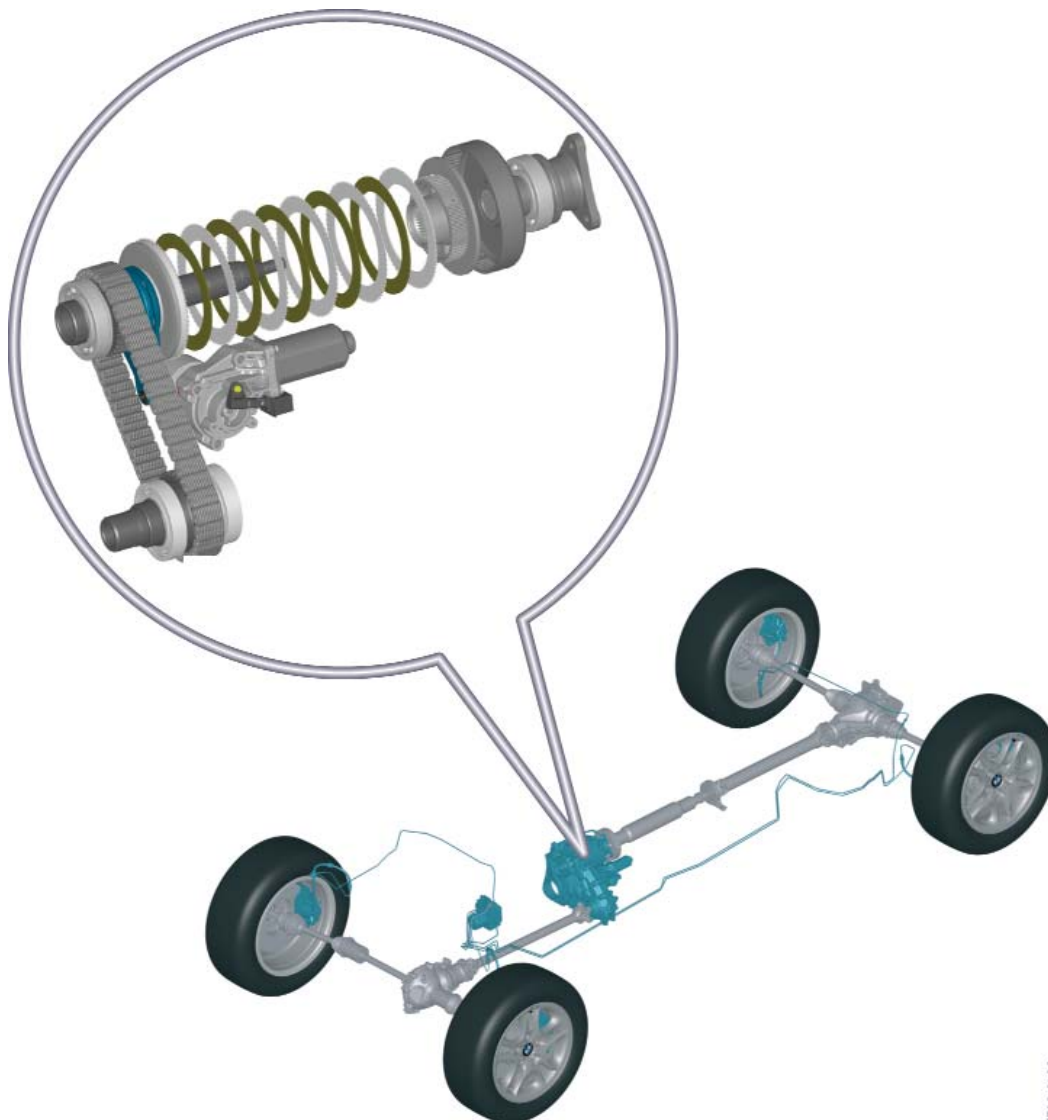
Purpose of the System

xDrive

The innovative xDrive four-wheel drive is a system that controls and regulates the distribution of driving torque to the front and rear axles. The measured variables of DSC are used by xDrive but are also influenced by modified handling performance.

The multi-disc clutch is the heart of the xDrive. By using the controlled multi-disc clutch, it is possible to resolve the conflict between traction and handling performance.

This is achieved through the fact that torque distribution is not determined by a fixed gear ratio in the xDrive as was the case in the previous systems. Instead, the distribution of driving torque is dependent on the locking torque of the controlled multi-disc clutch in the transfer case and on the transferable torque to the front and rear axles.

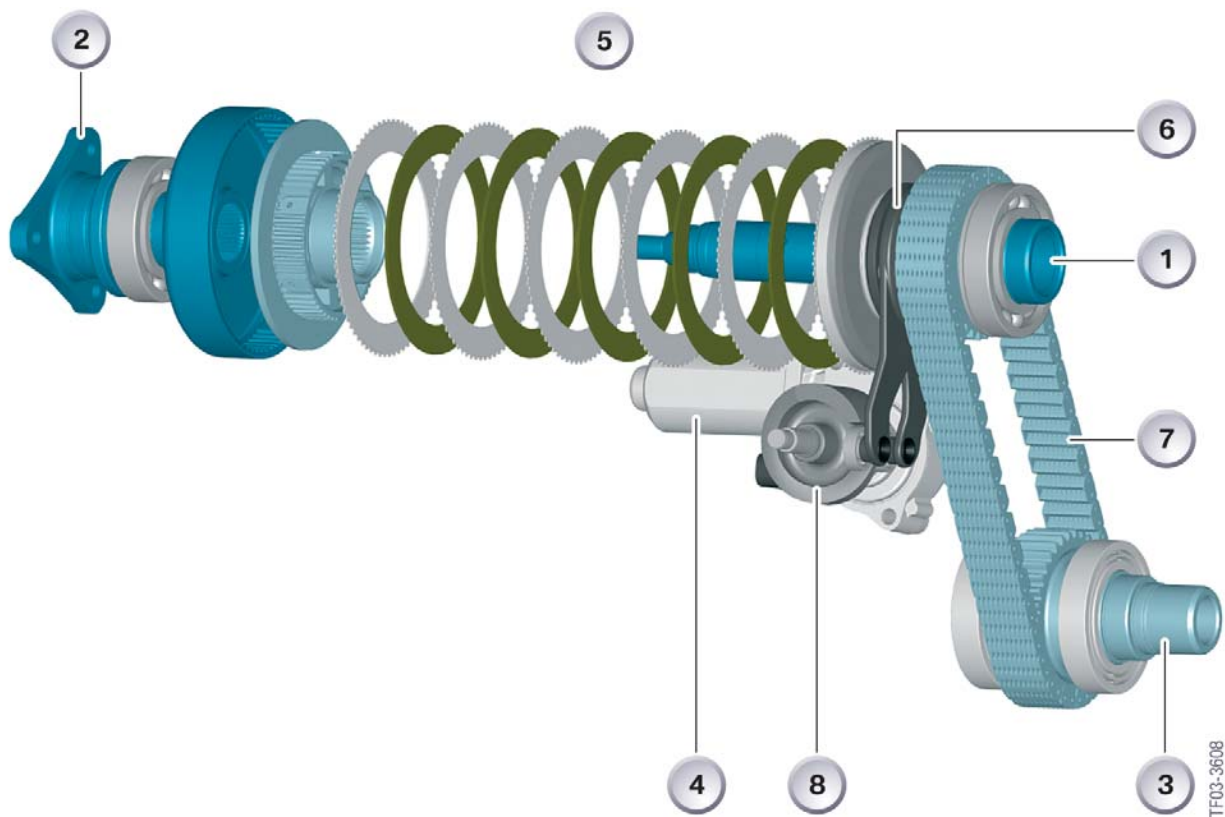


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xDrive - System Components

ATC 400 / ATC 500 Transfer Case

The ATC 400 is installed in the E83 and the ATC 500 in the E53 MU. They differ in that the ATC 500 is splined to the front propeller shaft and the ATC 400 uses a four bolt flange. In addition, there is one more disc in the multi-disc clutch of the ATC 500 and the distance between the input shaft and the output shaft to the front axle is 19 mm greater than in the ATC 400.



- | | |
|---|------------------------------------|
| 1. Input from manual / automatic transmission | 5. Clutch discs |
| 2. Output to rear axle prop. shaft | 6. Adjusting levers with ball ramp |
| 3. Output to front axle prop. shaft | 7. Chain |
| 4. Servomotor | 8. Disc cam |

The flange illustration of the ATC transfer case is the same for automatic and manual transmissions.

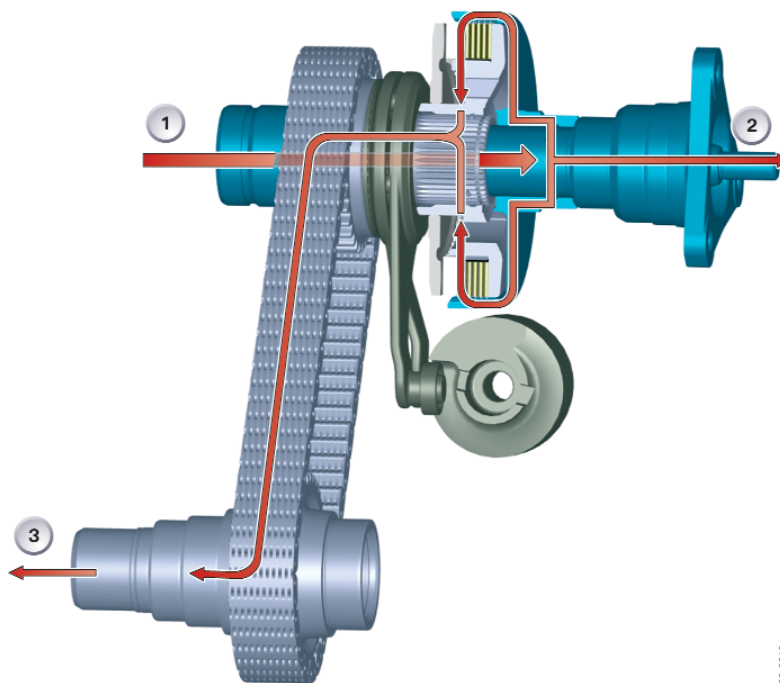
Power Flow

When the multi-disc clutch in the transfer case is disengaged, no driving torque is transmitted to the front axle. All of the driving torque is then distributed to the rear axle. This is because the input shaft (1) is splined providing a permanent connection to the rear axle propeller shaft output flange (2). The multi-disc clutch couples the rear axle propeller shaft output flange to the front propeller shaft output (3).

The driving torque on the front axle is increased or decreased by regulating the locking pressure of the multi-disc clutch, providing a stepless coupling of the front axle to the drivetrain. This depends on driving situations and road conditions. When the multi-disc clutch is fully engaged, the front and rear axles turn at the same speed.

Driving torque distribution (front/rear) is based on available traction at each axle. For example, when traction is identical on the front and rear axles and a driver accelerates from a stop in first gear at full throttle, the rear axle is capable of sustaining greater driving torque as the vehicle weight shifts from the front to the rear.

Another example is when the front axle is on a high traction surface and the rear axle is on ice. In this case, virtually 100% of the available driving torque is transmitted to the front axle. Based on available traction, virtually no driving torque can be supported by the rear axle. Obviously, when more driving torque is transmitted to the front axle, driving torque on the rear axle is proportionally reduced due to lack of traction.



TF00-3612

1. Input from transmission

2. Rear propeller shaft output

3. Front propeller shaft output

Note:

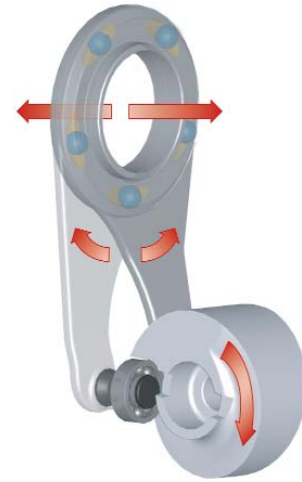
On a vehicle equipped with an automatic transmission, when driving onto brake analyzers, move the selector lever to the “N” position . On a vehicle equipped with a manual transmission, do not press the accelerator pedal once on the brake analyzer. This keeps the transfer case clutch open and the vehicle cannot be pulled off the analyzer.

Adjusting Levers

When the disc cam is rotated, it forces the adjusting levers apart.

The ball ramps create a precision axial movement which compresses and increases pressure on the multi-disc clutch.

This is completely variable up to a full lock.



Servomotor with Motor Position Sensor

The servomotor with worm gear are powered to rotate the disc cam.

The servomotor is a permanent magnet (1) DC motor which contains a Hall sensor (2) to detect the position and the adjusting speed of the motor shaft.

This is proportional to the degree of multi-disc clutch engagement.

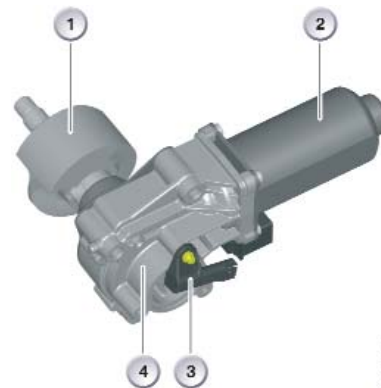


Coding Resistor

Because of mechanical tolerances in production, the characteristic curve of the multi-disc clutch locking torque varies slightly.

Once the actual locking torque has been measured on the clutch test bench, a resistor is attached to the servomotor; the resistor's value is a reference to the locking torque characteristic.

Each time the engine is started, the transfer case control unit measures the resistance value once and the optimum program map for the transfer case fitted is selected.



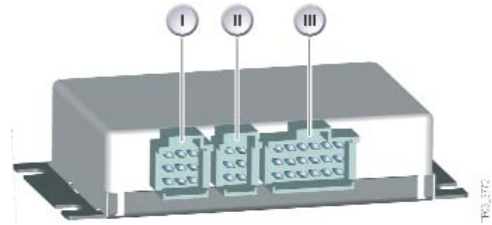
- 1. Disc cam
- 2. Electric motor
- 3. Coding resistor
- 4. Worm gear

Transfer Case Electronic Control Unit

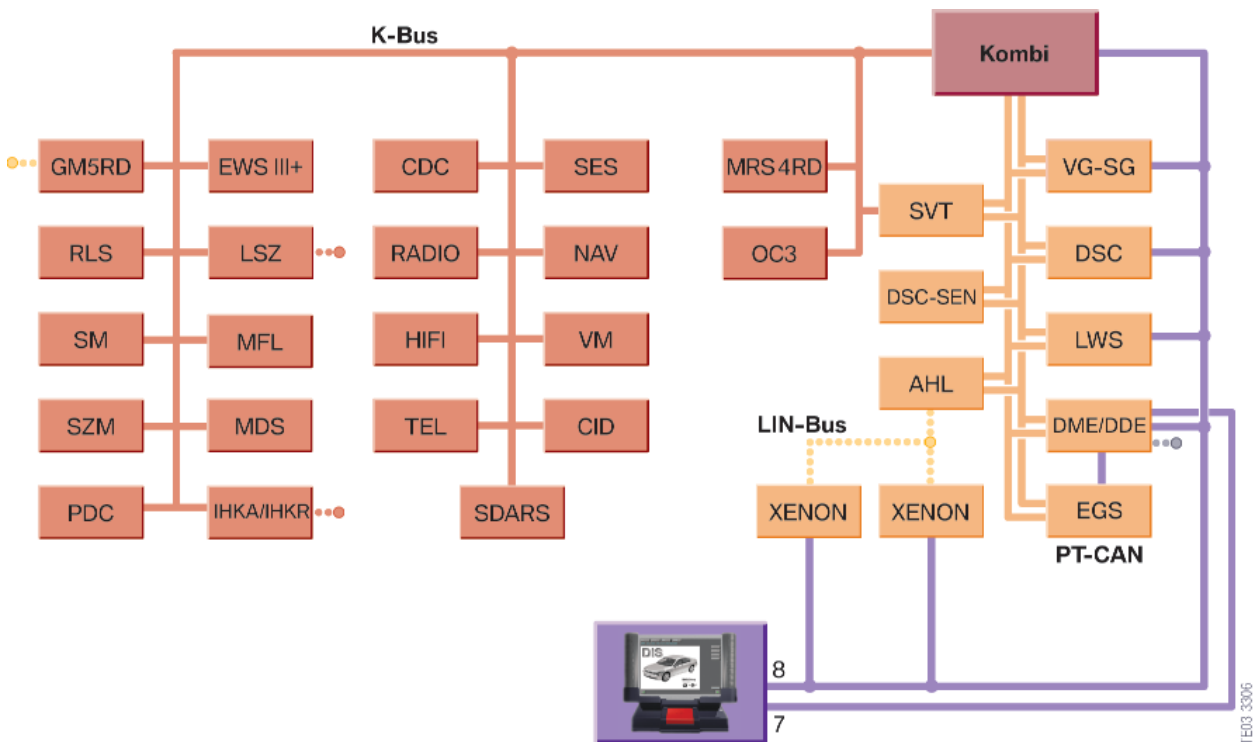
The transfer case control unit (VGSG) is installed in the E83 on the rear floor panel under the luggage compartment trim.

In E53 MU, it is located underneath the rear bench seat on the left.

- I. 9-pin ELO connector (not used)
- II. 6-pin ELO connector
- III. 18-pin ELO connector

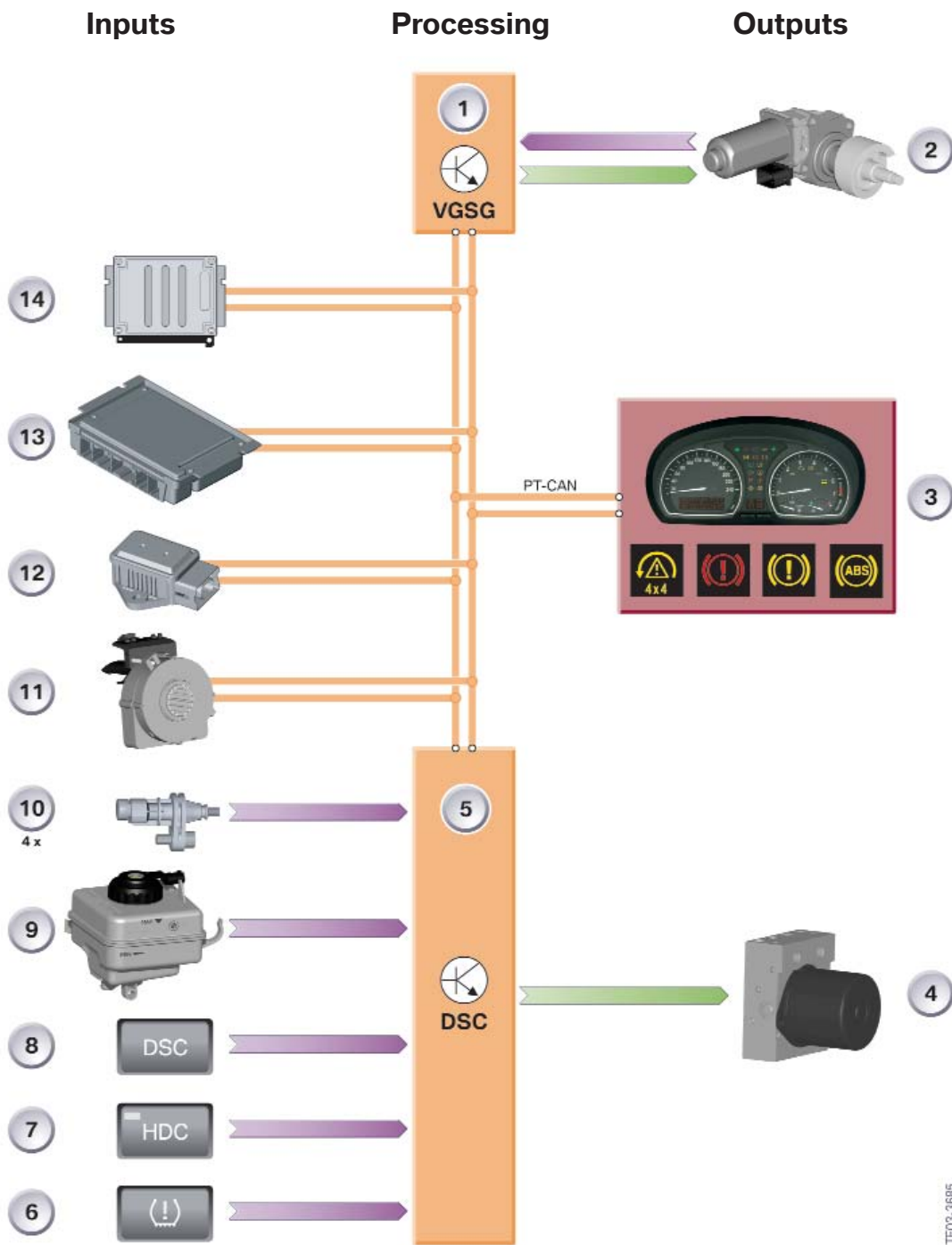


Bus Overview



The transfer case control unit (VGSG) is on the PT-CAN Bus. VGSG shares information with DSC for overall xDrive control and has diagnostic communication via the OBD connector .

Notes:



- 1. Transfer case control unit
- 2. Transfer case clutch servomotor
- 3. Instrument cluster
- 4. DSC hydraulic modulator
- 5. DSC control unit
- 6. RDW button
- 7. HDC button

- 8. DSC button
- 9. Brake fluid level
- 10. Wheel speed sensor
- 11. Steering angle sensor
- 12. Yaw/transverse acceleration sensors
- 13. EGS
- 14. ECM (DME)

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xDrive - Principle of Operation

xDrive

The transfer case control unit (VGSG) regulates the locking pressure of the multi-disc clutch in the transfer case. The transfer case control unit receives information on the required clutch locking pressure from the DSC control unit. The processing, control and electronics required for this are integrated in the transfer case control unit. This information is converted and output as a corresponding rotary motion of the servomotor.

In order to position the servomotor and compensate for wear, a reference run is carried out each time the ignition is switched off. The servomotor position is determined by a Hall sensor integrated in the servomotor. During the reference run, the clutch is engaged and disengaged completely (once). While the clutch is actuated, the current consumption is measured for the servomotor position. This allows the VGSG to determine the beginning and end of the clutch actuating procedure.

A clutch and oil wear calculation is also processed and stored in the VGSG. It increases the locking pressure as necessary in order to reduce friction.

In the event of DSC failure, the VGSG incorporates a fallback level (strategy) for activating the transfer case clutch in order to maintain the four-wheel drive function.

TCC

Regulation of the transfer case clutch (TCC) locking pressure allows stepless coupling of the front axle to the drivetrain. The driving torque on the front axle can be increased or decreased depending on the driving situation and road conditions. Obviously, when more driving torque is transmitted to the front axle, driving torque on the rear axle is proportionally reduced due to lack of traction.

The advantages of variable distribution of driving torque to the front and rear axles are:

- Optimum utilization of the cornering and longitudinal wheel forces on the front and rear axles.
- DSC brake interventions only become necessary at a significantly later stage, an increase in comfort refinement.
- Compared with an “open” differential transfer case and DSC, xDrive significantly improves driving torque distribution when traction on the front and rear axles is notably different.

The DSC control unit influences control of the transfer case clutch. Even when DSC is deactivated, TCC remains active for the purpose of maximum traction and driving dynamics.

Permanent four-wheel drive is only completely deactivated in three control situations:

- During very tight cornering with low engine torque to allow speed compensation between the front and rear axles (e.g. parking)
- At speeds > 180 km/h
- When the vehicle dramatically understeers

The transfer case clutch control logic is described in three main modules:

- Pre-control
- Traction control / driving dynamics control
- Tire tolerance logic

Pre-control

The pre-control logic (shared from DSC) reflects the driver's command and is calculated based on:

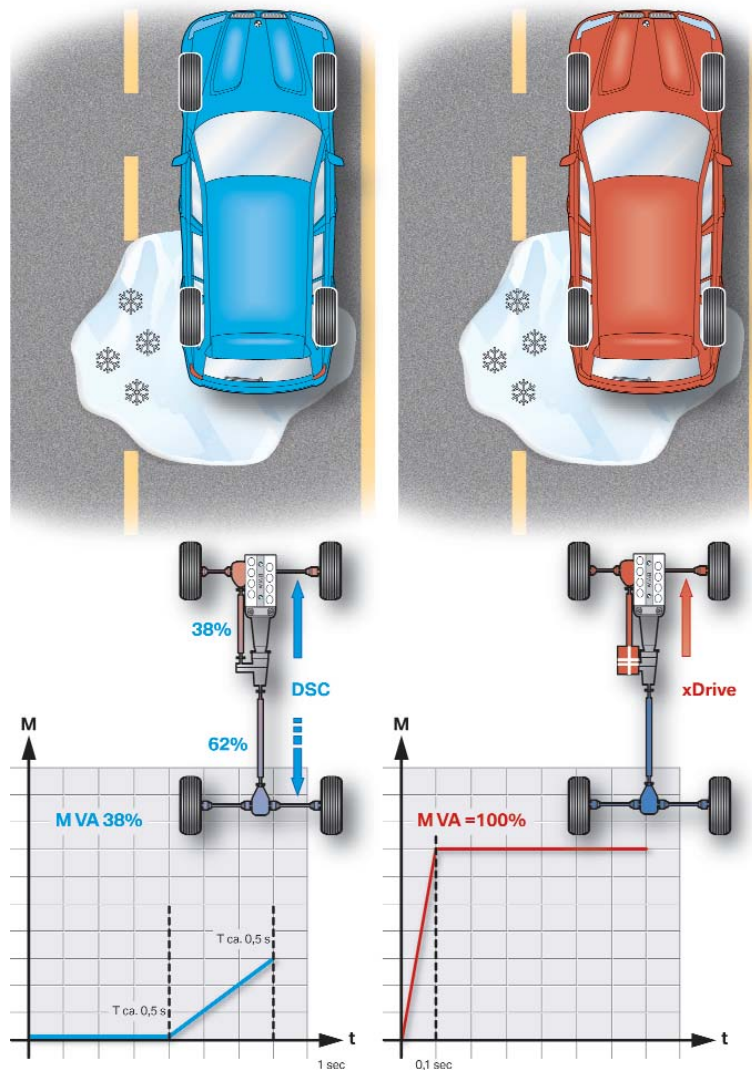
- Accelerator pedal value
- Engine torque
- Engine rpm
- Vehicle speed
- Gear
- Steering angle

In normal driving, the clutch is operated with minimum slip so that permanent four-wheel drive with a driving torque distribution of 40% on the front axle and 60% on the rear axle is available.

Even when the traction for the front and rear axles is dramatically different, the pre-control ensures that the system responds very quickly, as can be seen in graphic on the following page.

Notes:

“Open” Transfer Case vs xDrive



M = Driving torque

M VA = Driving torque on front axle

t = Time

In the case of the open transfer case, the brake is applied after slip is detected on the rear axle. This takes approximately one half of a second in reaction time. 62% of the driving torque is supported on the two rear brake discs and only 38% of the driving torque can be transferred to the front axle. In other words, wheel slip must be sensed first before driving torque is transferred through the transfer case by applying the rear wheel brakes.

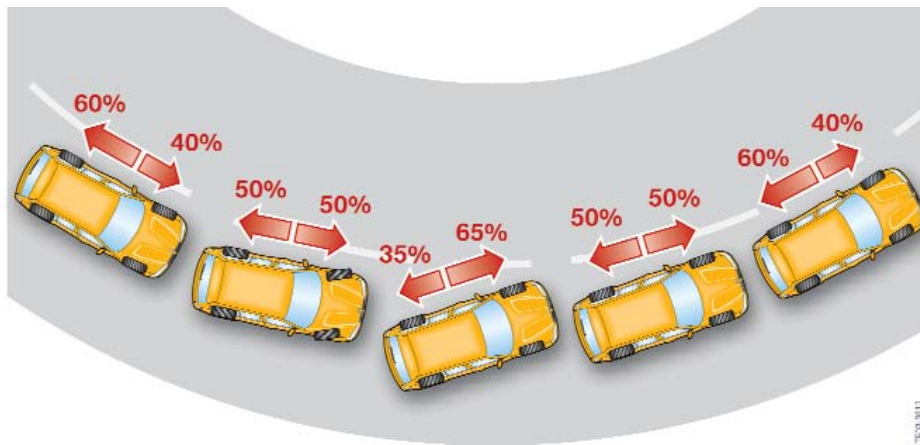
In contrast to an “open” transfer case (differential), the xDrive does not require brake intervention on the rear axle because no slip can occur (permanent through connection). The transfer case clutch is engaging the front axle as the vehicle is accelerating. This takes significantly less time (approx. one/tenth of a second).

Traction Control / Driving Dynamics Control

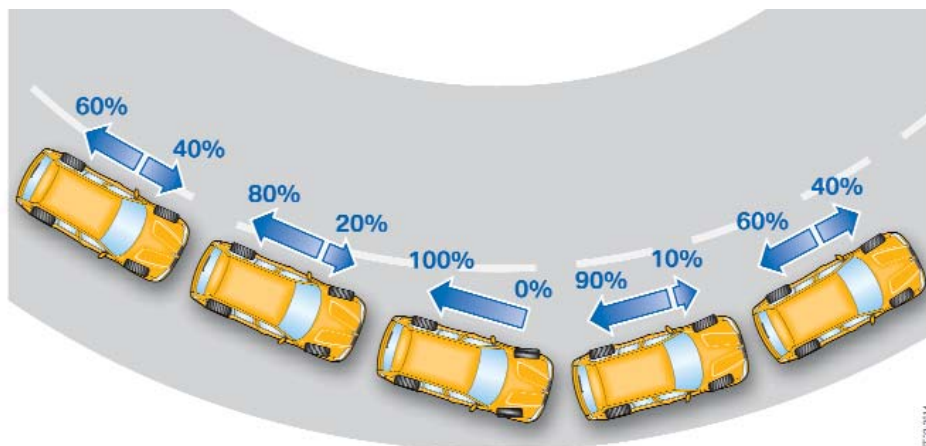
Traction control monitors the slip conditions on the front and rear axles. The wheel speeds, yaw rate and transversal acceleration serve as the input signals.

The function of traction control/driving dynamics control is to achieve optimum traction and to keep the vehicle stable.

As seen in the following graphic, in the event of an oversteer tendency, the transfer case clutch is completely engaged and the maximum supportable driving torque on the front axle is transmitted. This helps to “pull” the front of the vehicle until stability is achieved.



In the event of an understeer tendency, the clutch can be fully disengaged if necessary. In this example, the front axle is separated from the drivetrain and the driving torque can only be transmitted to the rear axle. This helps to “push” the rear of the vehicle until stability is achieved.



Tire Tolerance Logic

The tire tolerance logic detects different tread circumferences on the front and rear axles. This occurs when:

- Mixed tires are used
- Space saving spare tire is installed
- Tires are used that have been worn down to different levels

Normally, tire circumference deviations result in drivetrain torque bias (unwanted variations).

The tire circumference can fluctuate up to 1% or more as a result of mixed tires or wear. The tire tolerance logic decides depending on the driver's command and driving situation whether the slip is to occur in the transfer case clutch or at the contact area between tire and road.

If the slip is permitted in the transfer case clutch, the locking pressure set by the pre-control is reduced in order to keep the work loss low. In the driving dynamic control situation, the clutch is locked slightly more than normal, the four wheel drive is always guaranteed when required.

For maximum xDrive performance, tires (and wheels) of the same diameter should be installed on the vehicle.

Notes:



Workshop Exercise - xDrive Transfer Case

With the Instructor's assistance, perform the following:

1. *Disassemble xDrive transfer case. Familiarize yourself with the mechanical operation.* _____

2. *What are the differences between the ATC 400 and the ATC 500?*

3. *The multi-disc clutch (when engaged) locks what two components together?*

4. *What is the purpose of the adjusting levers and the cam disc?* _____

5. *Visually identify the coding resistor, why is it necessary?* _____

6. *When the E83 is placed on a brake analyzer (or dyno), what procedure must be followed for:*

Manual Transmission _____

Automatic Transmission _____

7. *The VGSG regulates the* _____
and receives information on the required locking pressure from the _____

8. *When the multi-disc clutch is not engaged, the E83 will always be driven by* _____

Why? _____



Workshop Exercise - xDrive on Vehicle

With the Instructor's assistance, perform the following:

1. *With the E83 placed securely on a vehicle lift and all 4 wheels off of the ground, start the engine and place the vehicle in a forward gear.*

Manual Transmission: release clutch pedal and observe which wheels are being driven_____ . Now press down on the accelerator pedal (slightly), what do you observe or feel? _____

Automatic Transmission: release brake pedal and observe which wheels are being driven_____ . Now press down on the accelerator pedal (slightly), what do you observe or feel? _____

Based on your observations, explain why this occurs: _____

2. *Apply the parking brake (completely). Start the engine and place the vehicle in a forward gear.*

Manual Transmission: release clutch pedal, what do you observe? _____

Automatic Transmission: release brake pedal and press down on the accelerator pedal (slightly), what do you observe? _____

Based on your observations, explain why this occurs: _____

3. *Is DSC braking application required to transfer drive torque from the rear output to the front output? _____*

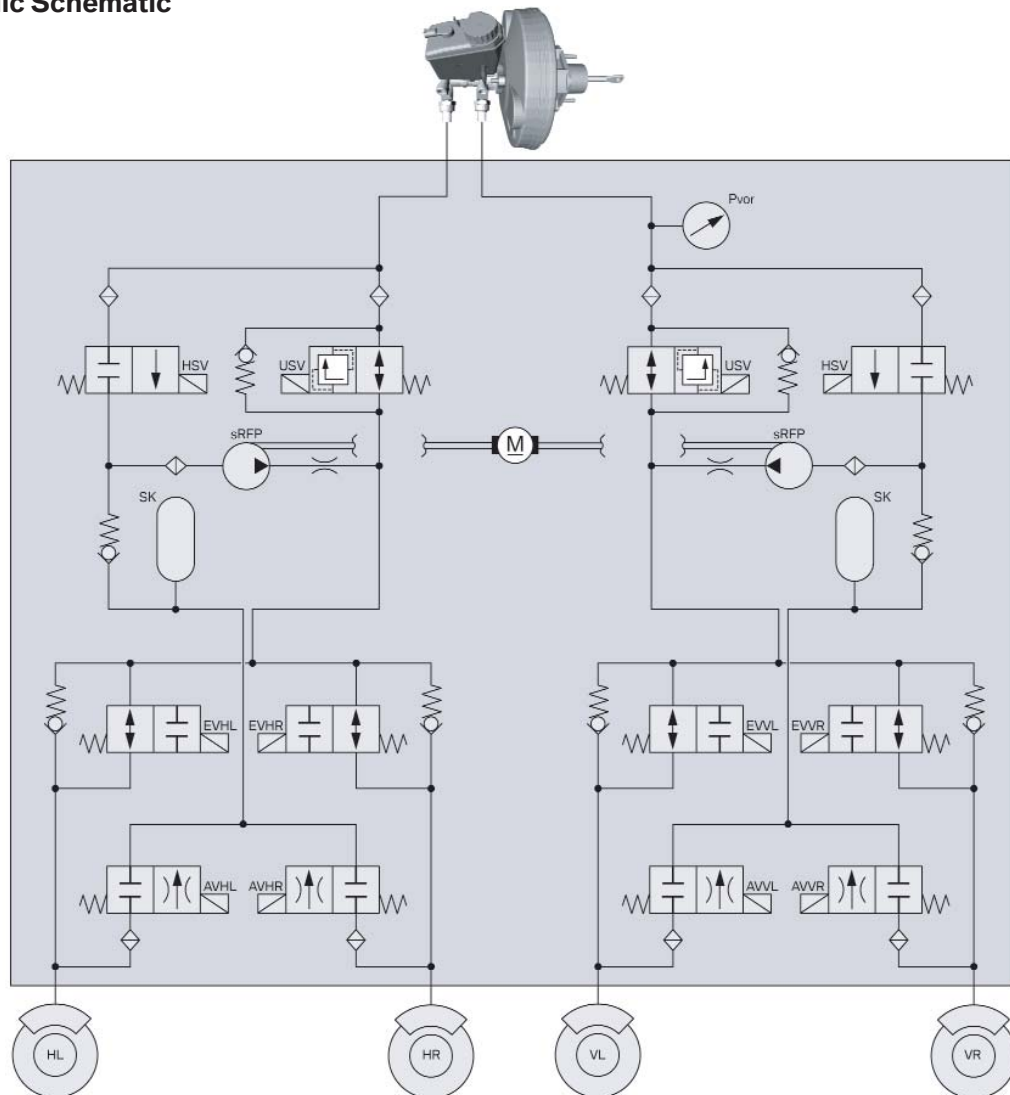
4. *DSC braking application takes place to provide: _____*

xDrive / DSC - System Components

The xDrive / DSC system consists essentially of those components from the familiar DSC8. The controllable multi-disc clutch in the transfer case is a new feature.

- DSC8 module
- Transfer case electronic control unit (VGSG)
- Yaw and transversal acceleration sensors
- Wheel speed sensors
- Pressure sensor
- Steering angle sensor
- Brake fluid warning switch
- Brake light switch
- DSC button
- Transfer case motor position sensor
- Coding resistor
- Transfer case servomotor

Hydraulic Schematic



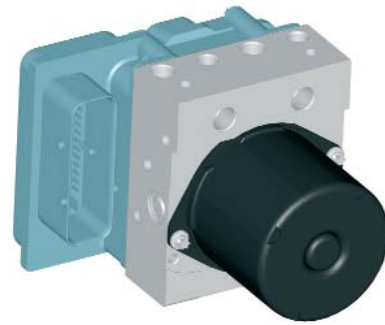
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DSC Module

The DSC module located in the engine compartment consists primarily of the following three components:

- Surface mounted control unit
- Valve block with integrated pressure sensor
- Pump motor

It is the same design as the DSC8 module which was introduced at BMW with the E60.

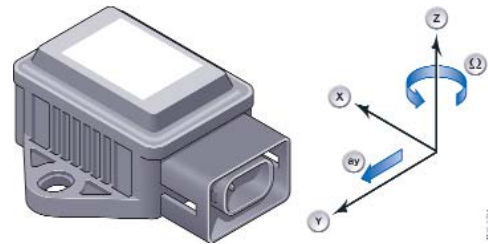


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Yaw and Transversal Acceleration Sensors

The sensor (assembly) in the E83 and the E53 MU is located on the transmission tunnel at the rear.

- X Longitudinal vehicle axis
- Y Transversal vehicle axis
- Z Vertical vehicle axis
- ay Transversal acceleration
- Ω Yaw



WKAJ274

Wheel Speed Sensors

The active wheel speed sensors require a supply voltage for operation and output a signal of non speed dependent constant amplitude.

1. Sensor ring (ferromagnetic wheel bearing seal carrier)
2. Sensor IC with Hall elements
3. Sensor housing



TXUJ302

The xDrive uses wheel speed sensors with an integrated evaluation circuit. The output signal is transmitted with the pulse width modulation (PWM).

The rising signal edge is used to determine road speed; the pulse width contains additional information on the direction of rotation, standstill detection, installation position detection and air gap reserve to the sensor ring. Direction of rotation detection is by the internal Hall sensor signals (like E65).

xDrive / DSC System - Principle of Operation

As featured in earlier DSC modules, the DSC8 mounted control unit also features two microprocessors. The surface mounted control unit also incorporates two semiconductor relays:

- One for the pump motor
- One for the solenoid valves

When a speed of 6 km/h (4mph) is exceeded, an electronic self-test is started which the pump motor and all the solenoid valves are briefly activated. When the brake light switch is activated simultaneously at that speed (for example: two footed drivers), the self-test is carried out at 15 km/h. Checking of the wheel speed signals is started at 2.75 km/h.

In the xDrive, the DSC also assumes the function of calculating the locking pressure for the multi-disc clutch in the transfer case. The locking pressure is set based on the driver's command and regulated as required depending on the driving situation.

The locking pressure produces the distribution of driving torque to the front and rear axles. The DSC sends the required locking pressure request to the VGSG via the PT-CAN Bus.

In turn, the VGSG signals the locking pressure actually set depending on:

- Transfer case fluid temperature (calculation based on locking pressures)
- Electric motor loads
- Multi-disc clutch loads

System Functions

The xDrive / DSC system comprises the following functions (same as E60 or E53 except for *):

DSC:

- ABS Antilock Braking System
- ASC-X Automatic Stability Control X *
- DSC Dynamic Stability Control
- EBV Electronic brake-force distribution
- DBC Dynamic Brake Control
- CBC Cornering Brake Control
- MSR Engine drag-torque control
- HDC Hill Descent Control
- ADB-X Automatic Differential Brake *

xDrive:

- TCC Transfer Case Control (previously covered)

ASC-X / ADB-X

Unlike regular road vehicles, SAVs are also meant to demonstrate satisfactory handling characteristics and appropriate traction on unconventional roads. In order to provide optimum propulsion with sufficient cornering stability on both normal roads and other road surfaces, Automatic Stability Control X (ASC-X) contains a detection function to distinguish between them.

When off-road terrain is detected, wheel slip threshold is increased to provide sufficient traction force with the increased levels of traction loss.

ASC-X is supplemented by the Automatic Differential Brake (ADB-X) function, which applies the brakes to the wheels per axle, for side to side torque transfer. For example, when a wheel is spinning on one side (up to the slip setpoint), the brakes are applied to that wheel and the driving torque is transferred through the axle differential to the wheel with the higher traction. This provides superb capabilities when there are diagonal traction losses (ie. left front/right rear).

ADB-X remains active when DSC is deactivated. Furthermore, ADB-X can develop full capability because the engine power is not reduced, even during extreme four wheel drive operation. Only that wheel which has a low traction receives the brake application.

The brake disc can overheat with excessive ADB-X intervention with DSC deactivated. In this situation, the operation is discontinued at a disc temperature of approx. 700 °C and is resumed when this temperature drops below approx. 400 °C. This is a calculation performed by the DSC control unit based on brake application time, pressure, wheel speed, etc.

Limp Home Operation

In order to maintain the four wheel drive function for as long as possible even in the event of important sensor signal failures or failure of the DSC control unit, a limp home control is integrated in the transfer case control unit. This control operates in redundancy to the transfer case clutch control in the DSC control unit. The limp home control contains only two control functions, precontrol and traction-slip control.

The wheel speed signals are very important to traction/slip control. Engine signals, steering angle and yaw are used predominantly for precontrol. If individual sensor signals fail, substitute values are calculated and the relevant functions operated with extended control thresholds.

This strategy is continued until useful four wheel drive control is no longer possible. In this event, the driver is alerted by the DSC/xDrive lamp coming on in the instrument cluster and also by an acoustic warning signal (gong).

Faulted wheel speed signals on the rear axle are calculated by driving or engine speed (remember, the rear wheels are always driven). If the front wheel speed signals fail, the values of the rear axle are adopted. Wheel speeds also substitute for a faulty steering angle signal.

Warning Indicator Lamps

The warning indicator lamps for the xDrive / DSC are found in the instrument cluster as shown on the right.

The warning indicator lamps and acoustic signals (gong) are assigned to the xDrive / DSC system states of malfunction described below.



DSC deactivated

no gong



**DSC faulty (ABS only)
or
VGSG faulty**

with gong



**Complete DSC failure
or
Complete DSC failure
and VGSG failure**

with gong



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Workshop Hints

CAUTION!!!

On a vehicle equipped with an automatic transmission, when driving onto brake analyzers, move the selector lever to the “N” position . On a vehicle equipped with a manual transmission, do not press the accelerator pedal once on the brake analyzer. This keeps the transfer case clutch open and the vehicle cannot be pulled off the analyzer.

Towing: Use only a flatbed carrier!

Transfer Case Oil and Monitoring

Please refer to BMW Operating Fluids for the required transfer case oil and specifications for the correct amount.

Oil Monitoring is performed by the VTG control module to determine when a service (change) is due. The VTG calculates transfer case and clutch wear based on the amount of slip, engagement pressure (torque), speed and mileage.

This calculation accounts for normal “dry” road driving, “adverse” road driving and “other” road extreme driving. Depending on individual vehicle use - driving styles and driving conditions, the transfer case oil service interval will vary.

When a service is due, this will be indicated by a Fault Code and additional details are available using the DISplus/ GT1. Service functions provide directions on changing the transfer case oil and updating the VTG control module with the necessary reset and adaption procedure. This is extremely important for CBS.

Diagnosis

Diagnosis is available for fault repairs and service procedures using the DISplus/GT1. When the tire tolerance logic is active, it can be read out in the fault memory.

Programming (flashing)

Both the transfer case control unit (VTG) and the DSC control unit are programmable and the new control unit(s) must be programmed when replaced. The wear values stored in the VTG control module (to be replaced) must be transferred to the replacement VTG.



Workshop Exercise - VTG Inputs/Signals

1. Using the DISplus/GT1, perform an automatic vehicle determination and locate the transfer case (transmission) control.
2. For the vehicle you are using, list the power supply sources and locations (power distribution, fuse box, etc.): _____

3. What are the connector and pin numbers for the Coding (classification) Resistor? Connector: _____ Pins: _____
4. Disconnect the harness connector at the VTG and perform a resistance measurement of the Coding Resistor. What is the value? _____
5. With the DISplus/GT1, access VTG - "Diagnosis Control unit functions". Select Diagnosis requests, Control module - Battery voltage to transfer case and Coding status. What values are displayed? _____

Additional Information:

6. With the DISplus/GT1, access VTG - "Diagnosis Control unit functions". Select Diagnosis requests, Transmission, Transmission integrator 1 and Transmission integrator 2. Select Display.

These are kW hours of wear on the transfer case calculated by the VTG control module (based on wear factors, refer to page 22).

Now select Clutch, Plate integrator 1, 2 and 3. Select Display.

These are kW hours of wear on the multi-disc clutch calculated by the VTG control module (based on wear factors, refer to page 22). These are deleted during a control module reset (oil service procedure).

Notes:



Workshop Exercise - VTG Outputs/Signals

1. Using the DISplus/GT1, locate the wiring diagram for the transfer case control.
2. What are the connector and pin numbers for the servomotor (actuator)?

Connector: _____ Pins: _____

3. Disconnect the harness connector at the VTG and perform a resistance measurement of the servomotor “drive motor” (inside the actuator). What is the value? _____

4. Reconnect the harness, and measure the voltage applied to the drive motor:

With key on (KL15) _____

Engine started _____

Raise vehicle on lift, place in a forward gear and accelerate slightly. _____

Set up a scope pattern and repeat the step above, what do you observe?

Record the duty cycle (%) while repeating the step above _____

5. With the DISplus/GT1, access VTG - “Diagnosis Control unit functions”. Select Diagnosis requests, Servomotor, Current consumption, Angle of rotation actual value and Display.

Start engine and record readings _____

Place vehicle in a forward gear and accelerate slightly _____

Now select Diagnosis requests, Clutch, Nominal clutch torque, Actual clutch torque and Display.

Start engine and record readings _____

Place vehicle in a forward gear and accelerate slightly _____

6. With the Diagnostic head connected, ignition “on” (KL15), parking brake “released” and transmission in “neutral”, raise the vehicle on the lift.

With the DISplus/GT1, access VTG - “Diagnosis Control unit functions”. Select Component activation, Servomotor and clutch.

Turn one front wheel by hand (slowly) and have a colleague select “Activate” while continuing to turn the front wheel steadily. What did you observe?



Workshop Exercise - VTG Service/Repairs

1. Using the DISplus/GT1, locate Service functions for the transfer case (transmission control) VTG.
2. What procedures appear in the Components column? _____

3. Select the Oil change service path, what component is “adapted” during this procedure? _____
4. Select the Repair service path, what “selections” are available?

5. When you select [3] Replace transfer case, does “Adaption” occur during this procedure? _____
6. When you select [4] Replace VTG control, what values are read out during this procedure? _____
What procedure must be performed with the values? _____

7. When you select [5] Enter wear values in new VTG control, what does this procedure prompt you to do? _____
What is provided on screen for you to accomplish this? _____
8. Return to the main component selection column and select Complete vehicle, Drive, Transmission control VTG, Transmission oil and Test plan.
Does “Adaption” occur during this procedure? _____
Is there an on screen indication about the condition of the transfer case oil? _____
If yes, what is displayed? _____

